

CHAPTER THREE: METHODOLOGY

Introduction

Ritchie and Spencer (1994) point out a notable growth over the last two decades in the use of qualitative methods in studying issues in the public policy arena due to the need to understand complex behaviors, needs, systems and cultures. To address these complex relationships, qualitative research offers the policy maker a theory of social action grounded on the experiences or world view of those likely to be affected by a policy decision or thought to be a part of the problem (Walker, 1985).

Roger Boshier (1980), a professor in the Department of Adult Education at the University of British Columbia, makes the case for engaging in research that is dedicated to developing theory, especially in young fields of inquiry as in the social sciences. He stresses that many social sciences are both a field of practice and an academic discipline in their own right, a good example being the field of Adult Learning and Human Resources Development. However, Dr. Boshier feels that the premium placed on applied research, prediction, and control has combined with the lack of indigenous frames of reference to create a situation where long-term and penetrating impact on these fields of practice cannot be achieved. He states that this is critically important for these social science fields of study since they are young disciplines moving toward long-term impact of understanding, prediction, and control. Thus, substantive theory development is a critical activity.

This particular research study does not easily lend itself to a hypothetico-deductive framework in terms of inquiry because of its reliance on context and system interrelationships in order to understand the phenomenon of FBC. The nature of the phenomenon and its complexity require a methodology that will allow immersion in the data and an inductive process of sense making that allows a theory to emerge. NASA is in the midst of constructing a new organizational reality, and this requires studying and observing the phenomenon through the experiences of people in the organization. Grounded Theory fits this research need.

The appeal of the Grounded Theory research methodology is that it allows for theory development specifically focused on adults in organizations and how they are learning to cope with change in transitioning from the old to the new. Frederickson (2000) offers a superb perspective on exploring the nature of relationships in organizations, where he emphasizes the capacities of perspective, experience, judgment, and the capacity to imagine in order to understand, in particular, public organizations and their management. This approach will illuminate both the creation of public policy in the new government environment and the implications that it will have on adult learning.

Sites and Subjects

The theoretical sample for this grounded theory case study began with recommendations of personnel to interview at the project level from the NASA Academy of Program and Project Leadership (NASA APPL). NASA APPL has been charged with the responsibility of preparing all NASA project managers in the successful implementation of FBC projects, as well as traditional projects. This organization possesses ties across all Centers of NASA and across all leadership levels in the organization, and knows the top performers in the Agency in terms of FBC and, perhaps more importantly, project managers that have struggled or excelled in FBC projects. This organization allows for access to personnel, projects and data that otherwise could be very difficult to obtain.

The mission of the NASA Academy of Program and Project Leadership (NASA APPL) is to provide total team and individual professional development support through training, developmental activities and tools for the organizational benefit of developing and maintaining world-class practitioners of project management, engineering, and science in advance of NASA requirements. The Academy also acts as a change agent for senior management initiatives and as a sensing mechanism for what is working and what is not in the project management arena through continuous conversations with NASA project managers in the field. The organization functions through five major initiatives: the Project Management Development Process, which emphasizes the practitioner aspect of developmental activities supplemented by academic materials; project management tools and information technology, which provides on-line availability of information and automated tools; performance support for intact teams, which delivers on-site developmental products and services to projects; a project management curriculum of training courses approved for graduate and undergraduate college credit by the American Council on Education (ACE); and research, studies & publications that advance project management practice through original research.

Research began by interviewing APPL-recommended personnel and observing project activities occurring in the Intelligent Synthesis Environment (ISE) project. Data was collected through these interviews of ISE team members, and then the theoretical sample expanded up to Enterprise and NASA Headquarters level. As the questions were focused on and refined on different research priorities, the sample then expanded to the Office of Management and Budget, further saturating the provisional categories developed during the initial interviews. For this research project, the sites consisted of a primary NASA Center that had responsibility for implementing FBC programs and projects, the Langley Space Flight Center (LaRC) in Hampton, Virginia; NASA Headquarters in Washington, DC for upper management and Enterprise data sources; and the Office of Management and Budget as an independent oversight organization data source. The theoretical sample expanded to a final count of 10 personnel, covering

five leaders of the Intelligent Synthesis Environment (ISE) project, the NASA Chief Financial Officer, the NASA Chief Operations Officer, and the three key oversight officials for NASA at the Office of Management and Budget (OMB).

Research Procedure

The research procedure began with discussions with NASA Academy on the selection of the initial theoretical sample from the organization for the interviews. These initial interviews commenced approximately three weeks from the approval date of the dissertation prospectus in October 2000. All interviews followed the tenets of Grounded Theory procedure that were outlined in the Data Collection section. The participant and initial interview list was compiled from the ISE project and interviews were conducted at LaRC during March through May of 2001, and expanded to the sponsoring Enterprise and functional offices in Washington, DC. The interview protocol was followed as outlined in the Data Collection section of this paper, and initial categories emerged. The NASA data were recorded and then transcribed on computer through IBM ViaVoice voice recognition software into Microsoft Word format. Once the data were transcribed, it was saved into *Ethnograph* qualitative analysis software that allowed for coding and storage of the data as outlined in the Data Analysis section.

The data collection and analysis proceeded in three major phases. The iterative process of data collection and analysis began with the first set of interviews at LaRC, comparing each of the interviews at the dimensional level, obtaining interpretations from several interviewees across the project organization, observing project interactions while at LaRC, and analyzing NASA documents and reports relating to the FBC process. The initial interviews focused on the development of categories, with subsequent interviews concentrating on attributes and criteria of FBC. New interview data points were reconciled with the developing structure and iteratively analyzed to saturate categories and to achieve integration and theory conceptualization. As the project progressed, the current literature search and new literature, documents, and experience (both technical and non-technical) were applied to the evolving properties and dimensions and stimulated comparisons at the dimensional level and honed the interview protocol so that categories were saturated and additional data points were developed. A pictorial theoretical model of the central phenomenon of FBC was developed following data analysis, including causal conditions, strategies, environmental conditions and context, and consequences, along with recommendations for future research, and a final report of the research in dissertation format was submitted for approval to the dissertation committee.

The Researcher

Creswell (1998) recommends that qualitative researchers must be able to set aside all preconceptions so that a theory can emerge from the data. Even though Grounded Theory is an inductive inquiry, researchers should strive to be systematic. Researchers should be aware when categories are saturated by maintaining sensitivity to repeated observations and trends that fit the same category. Attainment of the goal should be clear: a theory with specific components identified in the data analysis phase of the methodology. This includes a central phenomenon, causal conditions, strategies, environmental conditions and context, and consequences (Creswell, 1998).

Strauss and Corbin (1998) recommend that a good researcher in Grounded Theory possesses the characteristics of the ability to step back and critically analyze situations, the ability to recognize the tendency towards bias, the ability to think abstractly, the ability to be flexible and open to helpful criticism, sensitivity to the words and actions of respondents, and a sense of absorption and devotion to the work process.

One of the critical elements of the Grounded Theory approach is the iterative process by which data collection and analysis occur in alternating sequences. The balance between objectivity and sensitivity during this iterative process is a delicate balancing act that is difficult to maintain throughout the research process. Several techniques of overcoming this difficulty are addressed in the discussion of interview protocol under Data Collection.

Regarding Chapter II of this study, the literature review, Strauss and Corbin stress that Grounded Theorists use literature and experience as examples to stimulate thinking about properties or dimensions that can be applied to the collected data. The literature can hinder creativity if it is allowed to stand between the researcher and the data (Strauss & Corbin, 1998). However, literature should be used as an analytic tool that fosters conceptualization. Concepts derived from the literature can provide a source of making comparisons to data at the dimensional level. Literature can also enhance sensitivity to subtle nuances in the data set and provide a roadmap for what to look for in the data. The literature can be used to extend an existing theory of particular interest to the researcher. Literature can be used as an additional source of data, or can be used to assist in formulating questions for the initial observations and interviews. It can also stimulate questions during the analytic process in order to address discrepancies between researcher data and the literature. Areas for theoretical sampling can be suggested by the literature, as well as to confirm findings or to highlight inconsistencies and gaps in the literature. Nontechnical literature can also be used to enrich the interviews and observations in terms of a richer context.

In terms of my research background, one example of a useful literature element is the work of Donald Schon (1983). I feel that this example could have created a preconceived framing during the analysis, and it serves as a warning to be careful of restricting conceptualization by applying personal opinions of good research against the natural emergence of concepts from the research data. Schon said the process of Technical Rationality, where professional activity consists of applying scientific research-based knowledge and techniques to solve given problems of practice, was inadequate. Schon goes on to say that the tacit knowledge that he calls “knowing in action” is critical to understanding and improving practice, and is further refined by “reflecting in action” that is triggered by surprise. The context of the situation determines the deliberative moves of the practitioner, and they test their theories through the cycle of reflection, appreciation, and action. Schon’s concepts address a critical concern in public administration and other disciplines concerning the relationship between theory and practice, where he emphasized the contextual elements of research, knowledge embodied in action, one that brings together theory and practice (Schmidt, 2000). Grounded Theory fits this orientation very well in its emphasis on building substantive-level theory from data grounded in the organization.

Despite concerns of guarding against bias due to my previous education and research efforts, my personal experiences and education allow me to avoid several of the bias concerns mentioned in the previous sections. I possess military, private sector, and nonprofit experience that enable me to step back and compare incidents based on a broad and deep work background. Additionally, I have earned two Master’s degrees in the areas of Industrial and Organizational Psychology and Educational Administration, as well as several short training programs in areas as diverse as industrial experiments and team facilitation. Even though my research background has been mostly quantitative, this qualitative research study will allow me to expand my research capability and apply a wider variety of tools to research questions.

Interpretive Paradigms

How does Philosophy inform the approach of this particular Grounded Theory Case Study? Philosophy can be characterized as the systematic search for meaning. Domains of philosophy include the nature of human beings, the mind, the physical universe, truth, and moral reasoning. Philosophy allows us to point towards possible solutions through critical and reflective thought, gives us our perspective on how we view things, which determines how we will approach it, and from this we can generate models and theory. It allows generalization and informs practice.

Denzin and Lincoln (1994) provide a model through which they categorize interpretive paradigms. They identify four types: positivist and post-positivist, constructivist-interpretive, critical, and feminist-poststructural. This study works with the constructivist-interpretive paradigm, concentrating on the inductive process of

developing meaning that results in guides for future research. The goal is to generate an analytic schema relating to the NASA environment. A visual picture of the substantive-level theory can be developed so that the relationships can be clearly articulated.

Strategies of Inquiry

The Grounded Theory methodology concentrates on studying a central phenomenon and generating a theory from a category or “construct-oriented” approach. Similar to other qualitative approaches, the investigator is the primary instrument of data collection, and inductive fieldwork rather than deductive hypothesis testing characterizes the study. This methodology adheres to the constructivist-interpretive paradigm outlined above in that it searches for truth through the multiple realities as defined by the subjects, creates knowledge through the interplay between the researcher and the data that is derived from the subjects, and constructs substantive-level theory from data derived in context from the organizational setting.

Barney Glaser and Anselm Strauss are the primary developers of Grounded Theory through the publication of their book *The Discovery of Grounded Theory* (1967). Another primary Grounded Theory researcher is Juliet Corbin, who co-authored *Basics of Qualitative Research* (1998) with Anselm Strauss just before he recently died. Strauss graduated from the University of Chicago and was strongly influenced by interactionist and pragmatist writings. He was a field researcher by preference and by nature. Glaser graduated from Columbia and was a strong quantitative researcher that saw a need for comparing data to identify, develop, and relate concepts. Both the Chicago and Columbia traditions addressed professional and lay audiences.

Part of the appeal of Grounded Theory is that the methodology allows for creation and refinement of research questions as data emerge from interviews and other sources. The initial set of research questions hewed closely to the purpose of the study, which has always been to understand the theoretical underpinnings of a management philosophy termed “Faster, Better, Cheaper” (FBC), and uncover the interrelationships between the individual concepts as well as the organizational and technical requirements to support FBC, focusing particularly on the meaning of “better”. As the interviews progressed, it became clearer that FBC needed to be analyzed from the perspective of multiple stakeholders within and outside of NASA. As the study evolved, the requirement that the subjects for the study were NASA engineers in an FBC project expanded to cover public professionals that performed in hierarchical levels within NASA and others that provided oversight of the Agency in terms of management and budget. The research questions were adapted to address these issues, and an additional research question was added to address data that emerged covering specific workforce capabilities that were deemed important in implementing and applying the principles of FBC in NASA.

Research Question #1 focuses on the meaning of the concept of FBC for multiple stakeholders inside and outside NASA. There are potentially several characteristics or attributes implied in the context of defining each of the concepts of faster, better, and cheaper when operationalized by diverse stakeholders. In particular, given the difficulties in operationalizing the concept of “better” in TQM, BPR, and other organizational improvement interventions, Grounded Theory will assist in defining these relationships within the organization.

Research Question #2 concerns itself with uncovering the interrelationships between concepts of “Faster, Better, Cheaper” as perceived by stakeholders of NASA. The objective of Grounded Theory is to generate or discover a theory that relates to a particular phenomenon that people are involved with in the real world, thus “grounded” in data from the field. This methodology is particularly suited for the second research question, since the effective use of Grounded Theory can generate plausible relationships among concepts and sets of concepts, and the results can be reported in a flexible format. The Grounded Theory approach allows for interrelationships between concepts to be discovered, organized, and analyzed.

Research Question #3 focuses on how the technical and cultural structure of NASA influences the implementation of “Faster, Better, Cheaper”. The Grounded Theory methodology is again useful because it allows for the identification, development, and relating of concepts that exist within this technical and cultural structure. The methodology allows data to speak for itself; to be grounded in the context of the organization, thus is particularly suited for answering the third research question. The desired outcome is a theory that identifies the variables or categories from the data, and can result in further empirical testing and validation. Grounded Theory is rigorous, systematic, and strives to “saturate” observed categories with as much data as required to adequately describe the phenomenon of interest and to allow the emergence of a theory.

Research Question #4 addresses the topic of human development within an organization that is operating in a government reform environment. There are certain capabilities that will be required for personnel to implement and evaluate FBC programs and projects, and Grounded Theory will allow for these capability definitions to emerge through the use of examples of successful and failed FBC projects, and descriptions of the people who served on those teams.

Data Collection

Strauss and Corbin (1998) outline the process for Grounded Theory in their book, *Basics of Qualitative Research: Techniques and Procedures for Developing Grounded Theory*. A theoretical sample of the research population is generated and chosen, which is defined as a set of individuals that can contribute to the development of the theory that may

begin as a homogenous set of similar individuals and develop into a heterogeneous set when the researcher further collects, codes, and analyzes data, and then investigates the conditions under which these categories hold true.

The process of truth searching is facilitated through comparison groups that reveal similarities and differences, giving rise to theoretical categories. In this process, interviews are conducted in the field to saturate a category, meaning a point where no new information can be found to add to understanding. In this study, additional data will be generated using public documents, private documents, and NASA reports. The sequence of activity is an iterative process of gathering data/analyzing data that is referred to as a constant comparative method, resulting in a saturated category.

Interview Protocol

Strauss (1987) recommends that data analysis begin shortly following the initial interviews, or after the first day or two of fieldwork. Thus, any interview protocol will be tentative in nature as the data begins to point towards the development of categories. As mentioned, the nature of the questions will evolve as the research moves ahead.

Techniques for the control of bias were important in conducting the interviews. Strauss and Corbin (1998) offer several techniques that increase awareness and help control the intrusion of bias into analysis while maintaining sensitivity to what is being said in the data. These techniques were actively employed as the interview process progressed from initial interviews through follow-on interviews. The first technique controlling potential bias is thinking comparatively, which refers to the process of comparing incident by incident in the data, keeping the researcher grounded in the data, forcing data to be analyzed at the dimensional level. The second is to obtain multiple viewpoints of an event, allowing the researcher to gain distance through multiple comparisons by several actors. A third technique is to gather data through different formats, such as interviews, observations, and reports, allowing for triangulation and for variation to be built into the theory. A fourth technique is to revalidate data with respondents and see whether the research interpretation matches the actor's experiences. A fifth technique is to periodically step back from the data and to do a reality check, to critically assess whether the research interpretations fit the data. A sixth technique is to maintain an attitude of skepticism, keeping all research interpretations as provisional until validated by subsequent interviews and observations. The final technique is to adhere to the research procedures of Grounded Theory of making comparisons, asking questions, and sampling based on theoretical concepts.

The interview protocol was designed to achieve the gathering of the maximum amount of quality data possible that established and populated the categories for the theoretical construct. The initial preparation for the interview process consisted of a

presentation and a follow-up official written notification and request for support from NASA APPL to the ISE project that outlined the purpose and nature of this research study, the type of data that would be collected, the types of questions that they could expect, how the information would be collected and used (including privacy of sources and voice recording of information), the expectations in terms of involvement of the interviewees in the research process, and the feedback process that would be used, and the types of additional data and access that would be expected as a result of their participation. The initial interviews encompassed the ISE project team at LaRC, and expanded to Agency upper management levels (Chief Financial Officer and the Chief Operations Officer) for a total of seven Agency personnel, with the majority of the interviewing process occurring in the offices of the individuals interviewed and in the project field location. As the theory categories emerged and data saturated the categories, interviews were conducted with three personnel at the Office of Management and Budget responsible for oversight of the major Agency Enterprises.

In terms of questions that were asked in the interview process, different questions arise at different points in a Grounded Theory study, and this feature of the research process determined the nature and progress of the interviews as the study unfolded. At the beginning, they were geared towards the focus of the inquiry in terms of the research questions; in the middle towards specific questions on the phenomena as facts, assumptions, conclusions, values, and attitudes were clarified by previous interviewees; and towards the end on the integration to a coherent theoretical formulation. At times, the focus of the questions was towards substantive matters and towards theoretical issues. Strauss and Corbin (1998) offer suggestions for the types of questions that may be asked throughout the course of a research study, such as sensitizing questions that ask what the data may be indicating, theoretical questions that ask about process, variation, and connection among and between concepts, and practical and structural questions providing direction for sampling and help with structural development of the theory.

Since this research project impacts on public policy research, four general question categories were used in developing questions, probes and data collection activities (Ritchie & Spencer, 1994). The first category is Contextual, referring to the form and nature of what exists. Questions in this realm focused on dimensionalizing current attitudes and perceptions, explaining the nature of people's experiences, clarifying the needs of the population, and specifying where the subjects fit within a system. These diagnostic questions focused on the reasons or causes of what exists and addressed the factors underlying perceptions and attitudes, why decisions and actions are taken or not taken, why particular needs arise, and why services and programs are not used. Evaluative questions appraised the effectiveness of what exists, and addressed how objectives are achieved, what affects successful delivery of the program or service, how experiences affect subsequent behaviors, and what barriers exist to the system. Strategic questions identified new theory, policy, plans or actions within the

context of NASA. These questions addressed what services are needed, what actions are needed for effectiveness, how improvements can be made, and strategies needed to overcome newly identified problems.

Strauss (1987) discusses preparation for interviewers to recognize three particular elements during the interview process: conditions, interaction among actors, strategies and tactics, and consequences. Conditions were pointed out in interviews using cues such as “because”, “since”, “as”, or “on account of”. Consequences were pointed out through words like “as a result”, “because of that”, “the result was”, “the consequence was”, and “in consequence”. Strauss claims that interactions are discovered through the observation of actions other than the straightforward use of strategies and tactics.

Data Analysis

Data analysis in Grounded Theory follows a standard format, and is aided by preparation in the data collection phase. The researcher conducts open coding of data, segmenting information into categories, and dimensionalizing the information by discovering properties and subcategories. This is called conceptualizing, and is at heart the grouping of similar items according to defined properties and labeling them as a common link.

The researcher then conducts axial coding, organizing the information in new ways to explore causal conditions, strategies, context, intervening conditions, and consequences for the phenomenon. The goal is to systematically develop and relate categories. The result is a non-rigid coding paradigm or logic diagram that adds depth and structure to a category and integrates structure with process. It is termed “axial” due to the coding occurring around the axis of a category, linking categories at the level of properties and dimensions.

The researcher then conducts selective coding through a story line that integrates the categories in the axial coding model and refines the overall theory. Merriam and Simpson (1995) outline four stages to the constant comparative analysis of data. First, the investigator compares incidents, generates tentative categories and properties covering the incidents, and codes each incident into as many tentative categories as appropriate, keeping in mind any insights along the way. The investigator then integrates categories and their properties. Once this has been accomplished, the investigator delimits the theory by reducing the number of categories, developing hypotheses, and checking for proper fit of data into the categorical framework. The investigator then writes the theory from the coded data and memos. Conditional propositions or hypotheses are then presented, and a central explanatory concept is developed around which all categories are organized. A conditional matrix is created that illuminates the social, historical, and economic conditions that influence the

phenomenon. The researcher then trims off excess and fills in poorly developed categories through further theoretical sampling. Finally, the researcher compares it to raw data or presents it to respondents for reaction.

This study used a qualitative software data analysis package called *Ethnograph* to collect, code, organize, and report the data from the interviews, observations, focus groups, and the literature. This software package assists the researcher in noticing interesting things in the data, marking those things with code words, and retrieving those things for further analysis, or in other words compiling, organizing and manipulating these important things (Seidel, 1998). This package complements the Grounded Theory approach in that it enables the iterative process of collecting and coding qualitative data, or the constant comparative analysis process.

CHAPTER 4: ANALYSIS

Introduction

This chapter describes the analysis of the interview and document data collected for this research project. Sections discuss the categorization of the data and assigns meaning to the definition of a theoretical infrastructure for “Faster, Better, Cheaper” for NASA that emerges from the collected data. Attributes that describe the meaning of working “Faster, Better, Cheaper” and conceptual elements that are components of how personnel work to achieve the FBC ideal in a modern government project environment are described. These conceptual elements are discussed within the boundaries of the meaning of FBC, developing causal conditions, strategies, environmental conditions and context, and consequences. The resulting framework is further reinforced through an analysis of documents that address FBC, enriching the interview data and saturating the provisional categories. There are several internal documents and reports that address the meaning of FBC within the NASA context that include managerial guidance policies, NASA failure reports, case study documents, and special reports.

The overall analysis proceeded in four major phases as recommended by Locke (2001) for Grounded Theory research projects. The first stage compared incidents applicable to each category, assigning common meaning to multiple data observations, fracturing data documents into fragments through the use of *Ethnograph* software and creating basic line-by-line interpretations in an effort to assign meaning, using who, what, when, where, why, and how as criteria for dimensionalizing the data. From this, an initial data dictionary was constructed with multiple provisional categories. These initial provisional categories evolved into broader substantive categories following subsequent comparison and analysis using memos to capture and refine the definitions.

Stage two integrated the categories and properties so that the similarity and variation in the data incidents could be accounted for. This stage characterizes the properties of the data making up the substantive categories, and sets up the initial relationships between the categories for the theoretical infrastructure. Working relationships are hypothesized so that broader meanings are established, away from the initial comparisons of data elements against each other.

Stage three delimited the substantive theory, where major modifications are fewer and fewer in frequency and selected what was told and what was ignored as the primary research activity. At this point, subsequent data elements result in no new naming activity for additional categories. The goal at this stage is to have as complete an accounting as possible for data elements, while recognizing that the theory will not completely account for the phenomenon of FBC in NASA until subsequent research is conducted.

Stage four concerned the writing of the grounded theory, where the coded data, the memo sets, and the theoretical infrastructure contribute to the dissertation and produce future research propositions. This portion of the research is covered in Chapter Five of this dissertation, and integrates all of the analysis and findings of Chapter Four.

At this point, a review of the research questions would assist in understanding how the data analysis was conducted. The research questions guided this study, and served as the basis for the development of categories using the iterative research and analysis cycle of Grounded Theory methodology:

1. What does FBC mean for Public Professionals in the NASA organizational environment?
2. What are the interrelationships between concepts of “faster”, “better”, and “cheaper”?
3. How does the technical and cultural structure of NASA influence the implementation of “Faster, Better, Cheaper”?
4. What are the required workforce capabilities to perform “Faster, Better, Cheaper” in NASA?

Initial Data Analysis

During stage one, the interview data created multiple provisional categories of meaning, to include the interpretation of the management philosophy of “Faster, Better, Cheaper”. This data were assigned meaning through interpretations of the fragments of data elements, and categories were defined based on these defined characteristics. For example:

“I’m the type of person that prefers working on the personal level, though. Only if I have to, do I climb the chain of command and come back down.”

In the above quote from the interview data, several fragments emerge as important to the analysis, and contribute to dimensionalizing the data in terms of actions, conditions, values, attitudes, and situations:

- It is a very personal statement of preferred behavior by the interviewee, assigning an internal preference to how he interacts as a leader, illustrated by the fragments of “I’m the type of person” and “Only if I have to”.

- The data suggests an indication of formalized bureaucracy; illustrated by the fragment “I climb the chain of command and come back down”.
- The data suggests that this condition of bureaucracy not only has hierarchical layers, but also has a set of hierarchical layers that must be negotiated for cross-functional project activities to occur, illustrated by the fragment “climb the chain of command and come back down”. This is reinforced by historical records addressing the NASA bureaucracy and management documents that detail program and project management processes and activities.
- The situational aspects of the interview also contribute to assigning meaning to the data, in particular that the actor was a ten-year NASA veteran, possessing private sector experience, serving at a NASA Research and Development Center, and had to interact in his current project across organizational lines to several NASA Centers, putting a perceived premium on leadership as a desired capability.

This iterative comparison of data incidents applicable to each category and assignment of common meanings to data observations and fragments continued until all data could be categorized to the emerging definitions. Critical dimensions of the data assignments pertaining to who, what, when, where, why, and how were kept or discarded as needed to promote more accurate definitions or better insight to the meaning of the data. The data dictionary that was constructed from this initial analysis resulted in twenty-nine provisional categories. Using the Strauss model (1987) of defining interactions, consequences, and conditions, the data elements were also associated with these categories as well as the provisional meanings categories.

Provisional categories

The provisional categories reflect the entire gamut of capabilities, environmental factors, and behavior that are required to achieve success in an FBC organization, to include perceived definitions and interpretations of the terms “faster, better, cheaper”. These first 29 provisional categories represent all facets of the organization, as well as the contracting and oversight environment external to NASA, including the Executive Branch, the Legislative Branch, private industry, contractors, other Federal agencies, and academia.

These provisional categories were formed by comparing incidents, assigning common meaning to multiple data observations, fracturing data documents into fragments, and creating basic line-by-line interpretations in an effort to assign meaning, using who, what, when, where, why, and how as criteria for dimensionalizing the data. The initial data dictionary was constructed with multiple provisional categories and evolved into the 29 broader substantive categories following subsequent comparison

and analysis using memos to capture and refine the definitions in the Code Book (Appendix B). An example of this process is shown by taking a data element analysis from the sample interview contained in Appendix C. On line 233, the subject describes the pressures that accompanied the success of an FBC project called *Pathfinder*:

“I think it came from the top, I think from faster, better, cheaper, and trying to define it. It didn’t come directly from Mr. Goldin, I wouldn’t say that. It came from the way that people interpreted Mr. Goldin, and it came from the pressures that the Agency was under. I mean, do more with less. And basically, you know, it’s like you say, this boundary between having a streamlined efficient organization, and having an organization that’s overstressed and dysfunctional, is not a clear boundary, and I think the boundary in this case, for Mars, is somewhere between *Pathfinder* and *Mars Polar Lander*.”

In the software program *Ethnograph*, memos captured the comparison of this particular passage to other incidents that addressed a reduction of organizational layers that allow for achievement of results in less time as compared to past similar organizational efforts. In this particular passage, the subject emphasizes the reduction of organizational layers and resulting reduction in management processes that allowed the NASA *Mars Polar Lander* project team to make decisions at their level in implementing FBC. In further fracturing the data, two important dimensions of the data passage emerge where it can be seen that the team did not have any formal system to follow in implementing FBC, and that an artificial baseline was established from the previous *Pathfinder* effort, a project that cost twice the amount budgeted for *Mars Polar Lander*. In fracturing the data, the memo captured not simply the implementation of FBC in a less-complex decision-making environment, but that the *Mars Polar Lander* team was in trouble from the beginning, engaging in a process that added considerably more risk than the *Pathfinder* team had to address. The provisional code of “flatter” comes to signify a negative impact on the project in terms of words used, such as “overstressed” and “dysfunctional”. This dimensionalizes the category of “flatter” and is captured in the memo for this data element.

The provisional category of “flatter”, once dimensionalized, comes to address similar concerns addressing issues that revolve around the concept of organizational structure and management processes. Other provisional categories begin to address the same issues, such as “culture”, “more work”, “technology”, and “bureaucratic”, all of which cover observable patterns of organizational elements and management processes and interrelationships that allow the organization to achieve its vision, mission, goals, and objectives.

The categories and dimensions in the organization and management axial category were compared so that similarities and differences were accounted for, establishing the baseline for broader meanings. These provisional categories provided

for meanings that heralded a necessary transition to new imperatives from the old way of doing business in order to preserve research capabilities, drove an internal competition for a fixed set of resources that forced people to accept sometimes unreasonable risks, forced collaboration to achieve desired outcomes, and clarified that NASA personnel want to achieve success, but that organizational and management infrastructure often conspires against them. These initial definitions and relationships fed into the NASA substantive-level theory.

At this point, the coded data and memo sets were used to create and inform the theoretical infrastructure. The organizational and management axial category specified the Agency “pressures” that the subject discussed. These pressures are addressed in the “Government Causal Conditions” box in Figure 2, NASA Substantive-Level Theory. The organizational structure requirements and management processes are addressed in the FBC Strategy box and FBC Implementation Actions boxes that emphasize the “flatter” organization that was originally captured in the provisional category, and buttressed by the other provisional categories under the same axial category. The factors that work against “flatter” are clearly articulated in the Intervening Conditions box, and operationalizes the meanings of “overstressed” and “dysfunctional” originally raised by the interview subject. The consequences of an ill-defined FBC policy and assumption of greater risk can be seen as not leading to the Consequences and Outcomes box, where appropriate levels of risk and smarter choices are emphasized.

The evolution of the analysis process continued as illustrated in the previous process for each data element across 7 interviews and 1 focus group of 3 people. In each analysis component, the substantive-level theory was refined until the majority of data and substantive components were accounted for in terms of meaning and theoretical contribution. The provisional categories follow, where the definition of each provisional category is followed by a data example for each category discussion, with the critical fragment italicized in context with the overall data element.

Buy-in

This was defined as agreement, enthusiasm, and support, observable and otherwise, from individuals and organizational elements in NASA towards defined organizational strategy, including vision, mission, strategy, objectives, and tasks during the project lifecycle. Interview data centered on the importance of agreement and commitment needed for FBC projects to succeed in an organization that consists of ten diverse Centers and Headquarters. An example of this would be:

“But then we have to start dealing with the cultural issues of *do they want their processes fixed or not*, and showing them that these new technologies can actually be helpful to them.”

Communicate

Communicating was defined as oral, written, and nonverbal activities occurring at individual level through organizational team level in NASA that convey organizational issues in terms of vision, mission, strategy, objectives, and tasks during the project lifecycle. This was emphasized across the board within the context of providing leadership, and how good communication overcomes many barriers to success. An example of this would be:

"We were very compartmentalized under the old structure and you just can't run an integrated program like this with that kind of communication."

Capability

These are activities at an individual and team level in NASA that conveys a sense of competence and alignment with organizational preferences during the project lifecycle. One of the issues that emerged was that technical education and training was seen as critical to success in the Agency, but there was no consistent Agency-level model that was applied across all Centers. Industry experience was seen as a very valuable commodity, where employees had built technical capability through hands-on experience and applied these knowledges and skills in a mixed government/contractor team setting upon joining NASA. An example of this would be:

"It was very beneficial in several ways. First of all, I got hardware experience. I understood what it means to actually deliver a product to a bottom line, you know, where a company's got to make a profit."

Emotion

This was defined as recognition and regulation activities by individuals and teams concerning internal feelings and the feelings of other individuals and teams in NASA during the project lifecycle. In particular, these feelings were triggered by poor project communications, where team members felt that they were not kept informed of critical developments and decisions, and this in turn affected their performance and attitude. An example of this would be:

"You know, that was a huge detriment, because when you have that in the Program Office, even if the word doesn't get out, that the feelings and the attitude and the morale get out to the rest of the program."

Method

This category refers to activities implemented by NASA personnel and teams that exhibit the defined characteristics of particular leadership and management philosophies, and address their associated value system as applied to acquisition and work activities during the project lifecycle. In particular, the emphasis on doing more with less emerged as the goal to which all methods were aimed. An example of this would be:

“Or a Discovery mission or a Mir mission, where you are trying out new management techniques, and in the case of Mir, to try to get your costs down across missions, and demonstrate that you can do things more cheaply.”

Metric

This category refers to a defined organizational standard defined by NASA management that activities, outputs, outcomes, and processes are measured against to determine the level of success of project activities. Project personnel often commented on the effectiveness and relevance of these metrics. An example of this would be:

“I mean, there were indications throughout the project, but it was kind of hard to stop it once it got started.”

Motivation

This was defined as the reasons why individuals and organizational elements increased and maintained their level of effort towards achieving defined and desired end states. In particular, for individuals, it seems that commitment to public service addressed the issues of benefiting the United States and that working in NASA provided individuals the opportunity to engage in highly interesting and stimulating work activities. An example of this would be:

“It means, to me, that what I am doing should be a direct benefit to the country, and I should be very responsible with my time and my talents with respect to how I will conduct my business.”

Outsource

This category covers acquisition activities by NASA that promote the use of external organizations with specified core competencies that can help NASA achieve desired project end states more efficiently and effectively (faster, better, cheaper) than using internal organizational capabilities towards these project activities. This is

consistent with the overall emphasis of the Executive and Representative branches of the Federal government towards accountability. An example of this would be:

“There’s software out there, all over the place, that we can buy as a starting point. We’re not gonna recreate the wheel.”

Results

This refers to an orientation by NASA management towards comparing outputs and outcomes to defined success standards as revealed through associated metrics tied to project activities. This contributes to the process of managing science as opposed to conducting science. It is closely related to the metrics provisional category, but focuses on outcomes, and how activities and processes contribute to desired outcomes, such as scientific data. An example of this would be:

“Are there intelligent ways to go about defining a mission that gets you the same science?”

Rewards

This category refers to activities oriented to NASA individuals and teams that reinforce desired individual and team behavior in project activities. For NASA, this concerns the issue of how to reward highly educated scientists, engineers, and technical specialists that perform in a mixed government/contractor team environment. For NASA personnel, it seems that the nature of the work may be an intrinsic reward. An example of this would be:

“To tell you the truth, you know, I don’t know, I think we need to do a lotta work in how we actually have geographically distributed organizations, and I think if you look at it from a rewards and incentives kind of standpoint, it’s not that the individuals are all out there looking for specific rewards when they do a job, but when you reward the team, that makes a big impact.”

Systems View

This category covers activities by NASA individuals and teams that recognize and leverage the patterns and interrelationships between and among all organizational elements and stakeholders of the Agency. In understanding these patterns and interrelationships, this is a prerequisite for effective risk management. An example of this would be:

“Right now, we still have a ways to go in terms of being able to do an integrated analysis, to understand the performance, the cost, and the risk.”

Trust

This category addresses activities by NASA individuals and teams that impact the level of commitment by other individuals and teams for project activities. These activities are related to the organizational environment and pressures that result from NASA management. An example of this would be:

“Yeah, and so without that trust, you know, it’s very hard, it makes it harder to get the job done, particularly faster, better, cheaper.”

Better

These are NASA management activities directed towards improving project products and services over previous attempts in terms of schedule, cost, quality, technical performance, and customer satisfaction. This is particularly hard to define in NASA when the research mission has never been done before, making it difficult to make valid comparisons. Process improvements through the use of improved and advanced technologies often enabled NASA to achieve success that would have been impossible just a few years ago. An example of this would be:

“There are technologies that are better, and they might make things cheaper, and they might make things faster.”

Cheaper

In contrast and comparison to “better”, these are NASA management activities that lead to less expensive alternatives when compared with previous instances of similar activities in NASA projects. This reduction in cost to achieve research results can be seen as “better” in and of itself. An example of this would be:

“And cheaper is real quick, do it easy, you look at the dollars, and how much cheaper were you?”

Compete

This category refers to NASA management activities that allow several potential products and services providers to struggle against each other in providing a preferred approach for a customer. This is consonant with the overall Federal environment, where some politicians and public service professional are emphasizing that government needs to become more businesslike, to include embracing competition as a factor in Agency activities. One particular aspect of competition that detracts from effectiveness and efficiency is when there is a duplication of effort between NASA Centers. An example of this would be:

“There’s still – and this probably goes back – the source of this goes back some years – is *there’s still a fair amount of competition between the Centers*, and it’s I think the idea of setting up programs that unite the efforts of Centers is a very good idea.”

Cost

This provisional category covers alternatives for NASA project outcomes are compared to an expense criterion for decision purposes when conducting project activities. When comparisons are available for NASA, this highlights the impact of advanced technologies and how these technologies impact cost. An example of this would be:

“Pathfinder cost 1/20th of Viking, even inflating Viking’s cost to Pathfinder dollars – 1/20th – and was highly successful.”

Customer

This category covers activities by NASA personnel that concern customer focus and customer requirements to gain effectiveness and efficiency in providing these accurately defined products and services. For NASA, this is a critical activity that is difficult to accomplish, especially when NASA acts as its own customer. This category is also related to risk as one factor that needs to be addressed. An example of this would be:

*“We have a September deliverable coming up *that’s being driven by actual user input.*”*

Faster

Activities by NASA personnel that focus on achieving project results in less time, as compared to past similar organizational efforts. An example of this would be:

*“I mean, faster is clear, right? You just look at the schedule, and *how much faster you were than the previous guy?*”*

Interact

Activities by NASA individuals and teams that contribute to defining an optimal balance of effectiveness and efficiency. An example of this would be:

“The most important thing on Pathfinder was getting the job done right, which meant *coming in within budget, on schedule, but having a robust system* as reliable as we could make it.”

Mission

NASA individual and team activities that are tied to defined senior management statements describing desired end states for programs and projects. An example of this would be:

“And the longer term view of Human Space Flight, and this is where another element of strategy comes in, and that’s with the Space Launch Initiative, and the fact that Shuttle, if you look at Full-Cost, probably uses close to \$4 billion per year of the Agency budget.”

Political

Activities by NASA individuals and teams that may or may not be aligned to organizational culture and are characterized by compromise and conflict resolution in project activities. An example of this would be:

“But it’s one thing for the project to request your help in specific areas, and have you contribute, and it’s another for the political system to require that this be a multi-Center effort.”

Risk

Activities by NASA individuals and teams applied to mission and acquisition requirements that balance desired end states in schedule, cost, technical performance, quality, and customer satisfaction against constraints imposed by project type and resources. An example of this would be:

*“That’s exactly what I’m saying. You have to know *where you are in the risk space*, just like in the design space”.*

Similar

Project activities by NASA personnel that focus on lessons learned from past accomplishments as applied to present challenges. An example of this would be:

*“I mean, *the total cost for those two was the same as Pathfinder*. So it was two for the price of one, basically.”*

Bureaucratic

Organizational elements and activities tied to a clearly defined hierarchical structure containing specific roles, responsibilities, and expectations that impact NASA project activities. An example of this would be:

“You could see it but it didn’t dictate your life as much, and I worked for a small contractor, you know, we only had 15 people, and it was very easy to get things done, and then having to learn all of the procedures and processes that you have to go through in the Government for every little thing you do is just – it seems like it wastes a lotta time.”

Culture

The enunciation of the organizational value system of NASA that specifies desirable activities and behaviors for NASA personnel and team in attaining organizational objectives. An example of this would be:

“But in the Human Space Flight arena, they haven’t had that place within Human Space Flight where they can try out new things. When you’re trying out new things, that you need to put astronauts on it, or put people’s lives at risk, but they haven’t had that place to go.”

Flatter

Reduction of NASA’s organizational layers and associated roles, responsibilities, policies, culture, expectations, and personnel by NASA senior management for saving resources. An example of this would be:

“And basically, you know, it’s like you say, this boundary between having a streamlined, efficient organization, and having an organization that’s overstressed, and dysfunctional, is not a clear boundary, and I think the boundary in this case, for Mars, is somewhere between Pathfinder and Mars Polar Lander.”

More Work

Adding more work activities by NASA management to a remaining downsized pool of employees to compensate for flatter organizational structures, attrition, and downsizing. An example of this would be:

“It was probably the most stressful part of my career, not because it failed but just because there was so much to do in these 6 weeks, because they were so underfunded, really.”

Technology

Defined systems inside and outside of NASA that connect discrete NASA organizational elements into a connected pattern and enable interrelationships to form between individuals and teams. An example of this would be:

*“Well, I think there’s kind of a general realization that’s occurred over the last few years, that *the advances in information technology offer a great opportunity to improve all of our processes.*”*

Leadership

Activities that guide the organization to accomplish defined strategic elements (vision, mission, strategy, goals, tasks) under conditions of stability and change, and that encourage good decision-making from teams and individuals. An example of this would be:

*“People have to wanna do that, and so, yeah, up front, *leadership, setting the right leadership tone*, you know, creating an energy within the program is – is vital.”*

Axial Categories of FBC

Several dimensions that pertain to FBC emerged from the initial provisional categories following their creation. These categories and properties were compared so that the similarity and variation in the data incidents could be accounted for. This stage characterizes the properties of the data making up the substantive categories, and sets up the initial relationships between the categories for the theoretical infrastructure. Working relationships were hypothesized so that broader meanings are established, away from the initial comparisons of data elements against each other. These statements characterize the outcome that NASA is striving towards, and synthesizes an explanation as to the difficulties encountered along the way. The elements of FBC denote a philosophical view of how work should be accomplished within NASA. Thus, these elements of the interview data could be separated out as contributors to all four research questions.

The FBC interview data that emerged from the provisional categories revealed three conceptual elements concerning the interpretation of FBC and its management tenets. These conceptual elements included: doing more with less, to include interpretations of what the concepts of “faster”, “better”, and “cheaper mean; the importance of organization and management elements that enable or inhibit activities tied to the FBC paradigm; and finally workforce capability issues that allow for FBC activities to be implemented effectively and efficiently.

Doing More With Less

Personnel perceive FBC as a realization by NASA that the budget will not grow, so the organization must adapt to permanently constrained resources to achieve science. There is a real sense that the Agency must adapt to the times, and that the concept of continual improvement is important to operating in an FBC environment, because the pool of resources is finite, and that successful technical performance and scientific research does not justify an attitude of unlimited expense. The political realities of public desire for a smaller, more efficient government and the pressure of oversight organizations are forcing NASA to address how the research and operational money is spent. This forces a transition from a science and engineering focus to a managerial focus.

Desired Outcomes

One of the important dimensions of “Doing More with Less” is the definition of what FBC means, or the “Desired Outcomes” that exist within and outside of NASA. In discussions concerning the meaning of FBC, it is clear that the components of FBC are seen as desired outcomes gained by achieving efficiencies and increased effectiveness by focusing on smaller missions, incorporating advanced technologies, decentralizing program and project management to the Centers, and creating exciting visions and roadmaps. In particular, these advanced technologies are applications of science that were almost unthinkable only a few years ago, such as the rapid development and maturity of information technology, the development of collaborative communications technology and virtual environments and simulations, and the maturity of computer-aided design (CAD) and related tools and techniques, all part of an effort called the Intelligent Synthesis Environment by NASA.

Most conversations centered on the meaning of “Better” in the NASA project environment when defining FBC, and the difficulty in finding that definition. “Faster” was defined in terms of schedule, and “Cheaper” was defined in terms of cost. Definitions of Better covered technical performance, innovation, customer value, customer satisfaction, quality, team processes, and science. There is also the attitude of personnel performing in FBC programs and projects addressed as “continuous improvement”, demanding that personnel employ critical and creative thinking skills to drive innovation and never accepting the status quo. This has different meanings depending on whether the NASA component is research or operations. The capability of “smart” people figuring out a way to do things points to the necessity for innovation in the FBC project environment. Innovation may be a product of better creative and critical thinking skills in a team environment.

Willingness to Learn from Others

FBC possesses a particularly pragmatic view of the purpose of a Federal R&D organization, spreading risk across several categories of smaller efforts that realize a quicker return on investment in terms of science or improvements in operations that are transferred to the private sector, as well as to other components within NASA. This original intent of FBC is transitioning to a more private sector focused initiative that stresses the management of science through the importing and exporting of technologies and methods that will assist NASA and its contractors in meeting their responsibilities, a dimension concerning the “Willingness to Learn from Others”. This reflects the acceptance and inevitability of trade-offs in prioritizing science in an environment of decreased resources, where strategic partnerships and priorities are key to realizing successful outcomes, and where lessons learned from successes and failures can tremendously impact current efforts.

The lessons learned from these partnerships and previous efforts are essential across the entire organization. Trade-offs are often made through use of technologies, possibly from academia and the private sector, that are mature enough to achieve the mission objectives without increasing risk of mission failure, thereby driving down costs because of the increased gains in effectiveness and efficiency by the use of that technology. These margins defined by cost, schedule, technical performance, and customer satisfaction can be exploited by using the right technology, where internally developed or imported from outside the organization.

This activity of comparing to a baseline can be critical to the definition of Better, whether it is a previous effort, the effort of a competitor, or comparison to customer expectations of what is possible to accomplish. One reason that the Mars Lander project was such a complete failure is that the capability to provide telemetry data was sacrificed to remain within the cost requirements, thus making it impossible for any subsequent missions to learn from the failures of this particular mission. The explicit outcomes of learning from the performance of this spacecraft were not prioritized as an essential mission element. These comparisons can only be made if the relevant criteria are collected during internal testing and development, during the mission, and documented, an active effort to build in metrics that monitor processes, outputs, and outcomes, regardless of their origin. The emphasis on these metrics has shifted NASA towards a managerial approach where private sector business practices and metrics are being imported into NASA, contributing to the emphasis of managing science.

Balancing Requirements and Constraints

Another closely related dimension concerns “Balancing Requirements and Constraints”. FBC is achieved through balance and optimization of cost, schedule, technical performance, and customer satisfaction in an environment of safety and

constrained resources. Much of this risk is eliminated or mitigated through testing activities. The balance between too little testing and too much testing is an issue, for example, because enough information has to be captured in failures so that subsequent missions can learn and benefit from mistakes. Less testing results in less time, less weight, less cost, and more frequent missions. More frequent missions requires better lessons-learned so that success is replicated and errors are not repeated. This gaining of incremental knowledge allows for information to fill more and more of the unknown elements, and allows for the organization to gain efficiencies in cost, schedule, and quality.

The matching of FBC tools and techniques to the appropriate projects is a key element of managing the risk, especially in terms of unmanned versus manned systems. These FBC tools and techniques may well be very conservative incremental process improvements where crew safety is involved, as opposed to more radical risks that gain potentially big payoffs in scientific data in unmanned missions. Innovation can be achieved without sacrificing safety, but this is not currently done since the Agency does not manage programs and projects as a portfolio prioritized by risk, with lessons learned transmitted across the Agency. The transition from a scientific and engineering focus to a managerial focus in the application of FBC in NASA is reflected in the adoption of private sector business tools and practices that emphasize risk management, especially financial risk and the demand for a clear return-on-investment.

Making Outcomes Explicit

Many management hierarchies will just get someone else if a person says “no”. That is the fear that many project managers have, and it exists in NASA. It seems that the key is a dimension termed “Making Outcomes Explicit”, synthesizing a clear, organized case that contains options that are palatable and that achieve mission requirements, a very explicit conversation defining the expectations and constraints of the program or project. This requires good analytic skills as well as an ability to innovate to balance these often-competing elements of a project plan. This freedom to take risk is a difficult thing to achieve and maintain in an organization that exists in the public spotlight, and is held accountable for the spending of public money. However, the oversight personnel make very clear that they are forgiving of failure in the attempt to achieve great things, but not forgiving failure because of a lack of capability.

Interview Samples

Following are samples of interview statements that dimensionalize the overall axial category of “Doing More with Less”, with the salient data fragment italicized.

Desired Outcomes

"I guess a big part of it has to do with, you know, the current administration, but *I think that's kind of a general trend in the country, is that we tend to focus on near-term things that show a benefit with respect to the money that you're spending on.*"

"I think you can have all three. I think we had all three on Pathfinder, and I define "better" as *never accepting what you have as good enough. Always challenging it, always saying, "What if?", always asking questions, always pushing just a little bit better.*"

"You know, money and time correlate real well. It does not mean they're better. *Better is a discussion about better compared to what? Better than I would have had if I had nothing at all. Better you're like swarming gnats instead of a very heavy, gold-laced fly. Now, better science is starting to get close, because better science is a function of a lotta different things, like faster science is sometimes more important than slower science.*"

"I think better is dependent upon the type of mission that you're talking about. *If it's a spacecraft mission, better might be the ability to carry more instruments, and return more science. If it's an aeronautics mission, that's totally irrelevant. If it's an aeronautics mission, better might be fewer accident rates--or reduced accident rates for the civil aviation industry in the country.*"

Willingness to Learn from Others

"But then, once you get it into their hands, while you've theoretically proven that it can be cheaper, faster, and better, *it's new technology and there's inherent risk with new technology. By the time all the risk is mitigated, you've lost some of the faster, better, cheaper.*"

"My biggest fear is in the wake of the Mars failures, *that area within NASA that allows them to take those risks and try out those new technologically advanced things, new management methods will go away. We become so burdened by oversight, and other things, that you no longer have that capability.*"

"So there, faster, better, cheaper is a looking at the intended function within an environment and saying, *Do I need to give this the same nervous attention as I do something else that could kill me in a millisecond? Getting them to move further along that risk level, becoming less risk-adverse, requires them to gain incremental knowledge.*"

“Better is also if the point person gets so far out of view, that when you come across them on the trail, they're dead, you have no idea, what happened. So that guy has gone off and done his job but he hasn't done his job in a way that's helpful to you. So when the Mars program guys said we're not going to take telemetry on the way down, one, because it's hard to do, but, second, because on the way down, if you're having a bad day, all the telemetry tells you is you're having a bad day. *Now the next guy goes off and has to fix everything.*”

Balancing Requirements and Constraints

“They got the fact--in their case, their box was tighter than ours. They had the same schedules. They were just as fast. *But they had much less dollars, and they had, in my opinion, a harder challenge because of that.*”

“You can make it up if you've got a fat wallet, but 90 percent of these missions are faster and cheaper, and so there's a major disconnect there. *You know, you can cut one, if you got margin in another.*”

“They didn't have a lotta extra testing 'cause they couldn't afford it, and some of that was probably prudent, and probably should have been raised up, and someone should have said, *“Hey, look, you know, we're taking a little too much risk.” I mean, there needs to be a balance. That's what risk management, you know, is all about, is balancing, you know, faster, better, cheaper.*”

“I think there are ways that *we can be innovative without increasing risk, and that's sort of the balance that they need to subscribe to.* Willing to accept certain kinds of risks, and doing things that may be new ways of doing business. Then those risks aren't going to increase the safety risk to the crews.”

Making Outcomes Explicit

“The other aspect of it that overlies the component of the faster, better, cheaper, and that's the robotic spacecraft component, not the human space flight--*the robotic spacecraft component of it is that if you can promise people, give them a vision of flying more often, in less time, that you will achieve, concurrently, several things. One is they will take--they'll be less-risk adverse because the opportunity will be back again.*”

“I think had faster, better, cheaper not come along, space science would be in deep trouble. That said, there were some, on some of these missions, because there was not just explicit cognizance, as you said, *discussion of risk between the project managers and program managers, and their superiors, some stupid risks were undertaken, rather than undertaking a smart risk.*”

“If you haven't talked about risk with that program manager, he doesn't understand what he's supposed to deliver in terms of a risk profile for a mission, he may do stupid things in the other three areas, where, in the risk area, that will lead to mission failure versus if you have an explicit discussion of risk with him, he then has the opportunity to at least come back and say we can't do everything, maybe we need to take this instrument off the mission to bring the risk down, or we need to consider an increase in my reserves, or we need to consider this expansionary schedule.”

“If you're taking more risk, you have to expect failure. I think everybody accepts there's a certain amount of risk, but I think the thing that people should be afraid of is having failure because of stupid choices and where to take risk.”

Organization and Management

The FBC environment is characterized by specific conditions in organizational structure, management, and leadership context. As demonstrated by the Mars Pathfinder mission, FBC operates best in an environment of trust created by open communications, a small and dedicated collocated team that possesses a smaller number of project interfaces, easy contact with principles and a mixture of veterans with a high level of technical expertise and young engineers willing to learn, management buy-in with negotiated explicit outcomes, rewards for innovation, and consistent leadership that is willing to shield the project from internal and external threats. These projects were also designed to address the budget cycle realities of Congress and the current political environment, where the budget is driving public policy and complex and expensive projects without a clear constituency are easy targets.

Transition to New Imperatives

In the days of Apollo, NASA was conditioned to expect whatever resources were necessary to accomplish the mission. The dimension concerning the “Transition to New Imperatives” addresses a shift of a Cold War Agency to one that is more balanced in its approach and lives within its means. The political sensitivity and priority of the manned mission operations programs often require that research project budgets are raided to make up operations shortfalls. Poor communications about this topic creates a lack of trust between managers and the workforce, especially in the research projects that have their budgets raided. This trust is important, and is maintained by open communications about budget priorities and external issues that impact on the project.

As NASA becomes clearer in its identification of FBC capabilities, activities can be outsourced so that FBC concepts can be put into practice using organizational components of mixed teams of private and public sector personnel. The long-term

benefits for revolutionary change exist in the research arena, while manned mission operations require proven processes to achieve their goals and objectives due to safety issues. There is a feeling that NASA management does not recognize the issues that are important to the mission Centers and the Research Centers, and that both have to be addressed within a cohesive and prioritized project portfolio. Innovation plays a key role in defining what is possible, even in these larger missions. Management activities of continuous improvement and innovation both play important roles for NASA as a research and development organization.

Internal Competition for Fixed Resources

It seems, however, that NASA management wants to challenge the conventional wisdom without formalizing the process. Efficiency and effectiveness are additional customer requirements inserted as success criteria because of budget constraints. The process of FBC is rooted as a managerial tool to accomplish results more efficiently and effectively that still meet customer requirements. The realities of the Federal project environment increasingly require that this type of management behavior be employed with the appropriate programs and projects that demand a high level of innovation. As a government agency, NASA is shifting to a results orientation, not just focusing on process, addressing the dimension of “Internal Competition for Fixed Resources.”

Reinforcing and Enabling Collaboration

NASA learned its survival lessons well during the periods of increasingly constrained resources following the success of the Apollo program. The 1970s were a difficult time for the Agency as it continued to suffer withdrawal symptoms from operations conducted under the Apollo way of doing business. By the end of the decade, NASA personnel would drop from a high of 37,000 in 1967 to 25,000 (Sisung, 1999). The Centers built their own duplicate capabilities across the Agency in order to individually acquire their own programs and projects, neglecting the collaborative mechanisms. Out of this emphasis on internal competition emerges another dimension, “Reinforcing and Enabling collaboration”, that addresses the reward systems for individuals and teams. This system has historically not been developed and reinforced across the Agency due to political priorities. The boundaries between Centers stayed in place, and the management at each Center continued to reward behavior based on advancing the Center’s priorities over those of the Agency as a whole.

Desire for Change

There is a dimension of “Desire for Change” that emerges from the data. The employees at NASA clearly express their desires to do a better job, and want more responsibility and resources to implement FBC, but in many ways the current environment prevents them from achieving success. A central canon of the Agency has

always been to focus on and obtain approval for large expensive programs that are difficult to kill once they are underway, lessons learned from the Apollo era. As a result, a realistic Agency risk portfolio for a smaller set of NASA programs and projects was never emphasized or developed, preventing a full assessment of the priorities needed to move the Agency forward in an environment of constrained resources and a management culture that supports these types of efforts. From this, the required structures and processes that allow for an integrated approach to missions and research are not developed or are actively resisted. FBC projects that would benefit from a small cross-NASA and contractor team and focused approach are instead mandated to include Centers for political rather than performance reasons.

Interview Samples

Following are samples of interview statements that dimensionalize “Organization and Management”, with the salient data fragment italicized.

Transition to New Imperatives

“There's certain organizational initiatives that they see as their mission that they've inherited after decades of space flight, and that doesn't necessarily align with stakeholders, and *it's our job to act as the intermediaries that try to get NASA to align their mission with their activities, and what they're trying to do with the stakeholders, and that can be a tough job sometimes.*”

“We want to take some high risks, try out some new things with NASA to see if we can't do things faster, better, cheaper. At the same time we also want to make sure that we're advancing the science along and doing things that we need to do to get the job done. *So you kind of have to have this balance of missions, and it's sort of the program manager's job, and headquarters job to make sure that they have that right balance of risk across the missions, so that they are getting sort of the best return for the buck. You have to be able to communicate to your program manager or project manager- you're an Internet stock or you're a Treasury bond.*”

“Maybe I won't hit him with as much attention as I have. I won't bring 25 NASA engineers out for every damn meeting. *I'll put some reliance on the contractor to do a good job, and then instead of inspecting in the quality, I will do a reasonableness check on their stuff.*”

“I think when you're defining faster, better, cheaper, *you gotta differentiate a mission type, a faster, better, cheaper mission, a Discovery, a New Millennium type mission, versus a philosophy of continuous improvement across all, everything that NASA does to try to make things more cost-efficient, get more science for the dollars. I think the agency has to do both things. I think they always have to*

have some part of each enterprise within the agency that tries out the new, innovative, cutting edge, low cost types of things but then they need to be working on a continual improvement across the agency as well."

Internal Competition for Fixed Resources

"They don't realize that there are two very distinct types of organizations within NASA. *There's the mission center and there's the research center.*"

"Also to get them to play with the other centers, and, you know, *they're always fearful that their turf is being infringed upon*, and trying to expand things, and so on."

"Technology budgets are terribly unstable because they--my observation is that those programs are the salvation when the other big programs get into trouble. *They'll raid the technology budgets.*"

"But it's one thing for the project to request your help in specific areas, and have you contribute, and it's another for *the political system to require that this be a multi-center effort.*"

Reinforcing and Enabling Collaboration

"*The Centers have no desire to be one NASA.* Instead of trying to force one NASA, maybe your best products are these, your capabilities are these, and when the two meet, God bless you."

"Part of the problem is the *structure of the development team does not follow management structures.* You have no actual impact on somebody at another center."

"But if you would allow me to reproduce the environment that Pathfinder operated in, which was--*the team was allowed to be isolated, so they focused on the job at hand, and the sponsor at headquarters was willing to do anything to help us do our job as opposed to, you know, putting up roadblocks and being a poor communicator, and things like that.*"

"I think the other element of faster, better, cheaper was thinking outside the box with those bigger missions, and I think CERTIF is a good example of that, where *it was originally billed as a behemoth kind of satellite that was in a normal kind of orbit, and then when people were challenged with thinking outside the box, it isn't we're going to increase the risk because we're going to spend less money on it.* I think the challenge

was you need to think outside the box from how you've normally done things, and that got them thinking in this, you know, elliptical orbit.”

Desire for Change

“If NASA wants projects to succeed, *you have to build an environment where they can succeed*, and constant changes in funding, and so forth, make that virtually impossible.”

“They have to have the courage to say this is a program that we're just gonna have to drop, so that we can maintain the quality of the others. *Here they tend to kind of maintain--they don't want to hurt people's feelings, so they don't cut anybody out, but they just make everybody take a little bit less.* To me, that kind of kills your better, faster, cheaper. It definitely kills the "better" part of it.”

“But in Human Space Flight culture has been essentially *we do what we do and it costs what it costs, rather than thinking outside the box a little bit, and living within the resources that are available*, and the sort of inherent challenge has always been preserving safety.”

“You know, it's the same theory of change agents in the organization, that they have the "fire in the belly" to go do these things. We don't have to tell them this is a faster, better, cheaper program. *Just do it, and if it's faster, better or cheaper than the last one you did, claim victory.*”

Workforce Capability

The axial category of workforce capability emerged from the data across all interviews and across all levels of work performance, ranging from project team level through NASA senior management to outside monitoring agency personnel. The four dimensions of workforce capability directly address research question four. FBC projects require certain types of knowledges, skills, abilities, and attitudes in order to be successful. The following dimensions address the particular needs of the Agency as it struggles to perform under an environment of cutbacks and budget instability.

Public Service Orientation

The dimension of “Public Service Orientation” manifests itself in statements concerning work activities in the Federal government, and is characterized by the desire for public service and the nature of the work environment within NASA, specifically the challenges provided by a research and development organization and the pragmatic concerns of sacrificing monetary advantage in the private sector. Included in this is the underlying current of being responsible for something that is important to the country

as a whole, and that this responsibility for stewardship of Federal programs and projects is an important responsibility. The notion of sacrifice is a strong element, balancing the interesting work environment against clear-cut advantages of financial gain in the private sector. The security of performing as a civil servant is a factor that offsets this promise of financial gain. The unique motivation of working for NASA is clear for NASA employees, and raises the issue of how to influence the attitudes, values, and behavior of personnel that are integral to the success of NASA but are not NASA employees.

Leadership of Mixed Private and Public Sector Teams

The dimension of “Leadership of Mixed Private and Public Sector Teams” covers the individual characteristics of leaders, functional behavior of leaders, and organizational leadership elements that concern influencing people in a team that are motivated by two very different philosophies: making money and public service. Leadership activities are similar in both private sector and public sector teams in terms of motivation and performance. Both environments require buy-in and demonstrated leadership capability and behavior, as well as a healthy attitude towards change and a personality that works well in a team setting. This includes leading by example, using mistakes as learning opportunities rather than assigning blame, promoting buy-in from the team, and viewing change as an opportunity. However, the culture and structure of the organization, if it espouses innovation and creativity, needs to support these values, attitudes, and behavior in its project teams in order to achieve results. Leadership plays an important role in defining, supporting, and coaching for this to occur, and these leaders must gain experience and network to become effective. This seems to be especially true for scientists and engineers who gain their reputations through technical capability or knowledge, but then must learn to lead a mixed team.

Leadership behaviors that engender trust, integrity, and loyalty emerged as critical elements for leaders of mixed teams, just as they do in exclusively public or exclusively private sector teams. In particular, NASA leaders are respected for being realists and unafraid of carrying bad news when necessary, but this seems to be the exception rather than the rule. Overall, the lack of a workable leadership model across NASA contributes to many definitions of desired leadership capabilities at each Center and for each Enterprise, especially when married to required organizational roles. The political situation across NASA Centers does not allow Agency-level leaders to develop, manage, and lead effectively, due to the autonomous nature of the Centers as a historical artifact of NASA cultural development that often is difficult to change. This leads to parochial behavior that can sacrifice overall Agency science initiatives, as well as result in different views of what it means to be a good leader for each Center.

Since the majority of work at NASA is already accomplished by a combined public sector and contractor workforce, these issues within NASA become extremely

complicated. NASA leaders may not be cognizant or committed to Agency goals and objectives, thus unable to achieve the necessary buy-in and insight or oversight activities for the program or project that they lead. These leadership processes tend not to be written down, as in the FBC philosophy. Stewardship of the public dollar is NASA's responsibility, but there is no education or structured development process that allows for NASA project managers to transform themselves into better leaders of mixed teams. As mentioned previously, this compounds the issue of the NASA structure encouraging the creation of parochial leaders, concerned about the survival and prosperity of their particular Center as opposed to the survival and prosperity of the overall Agency as a whole and the achievement of National goals and objectives.

Acquisition Capability

The dimension of "Acquisition Capability" addresses the knowledge, skills, and abilities involved in obtaining products and services from the optimal source in terms of best value, to include public, private, and academic sources. Requirements definition and balancing risk emerge as key considerations in acquisition capability, aligning with the descriptions of FBC. The structure and culture of NASA does not support the espoused philosophy of FBC in many instances. This is in contrast to oversight elements indicating that smart risk should be encouraged due to the emphasis that the restrictions of a tight Federal budget are a key consideration in applying a successful acquisition strategy, and there is now a fundamental emphasis on achieving practical results. Because of this, acquisition capability needs to emphasize low-cost and near-term gains to survive in the current budget environment, as well as leveraging private-sector partnerships.

The reasons for improved acquisition skills are many. The requirements of the science community are historically second behind operational concerns. The transition to FBC was in part a way to save the research capabilities of NASA in the face of rising manned space flight operational costs, preserving research capability for the Agency. Research as an activity is required to compete just like everyone else in the organization, sometimes putting at risk the best parts of NASA's scientific research capability. The management of science is emphasized over the science, which may not be "faster", "better", or "cheaper". The short-term focus of FBC theoretically ensures improved budget stability for research projects in the face of rising operational costs, but the cost growth of operational missions sabotages the implementation of FBC projects by simply occupying a higher Agency priority, taking money from research programs whenever it is deemed necessary.

The overall stability of the Agency's budget also emerges as a critical concern for research programs, since research is a notoriously difficult thing to budget for, especially in an unstable budget environment. Critics inside and outside of the Agency are advocating a number of initiatives that strengthen the ability of NASA to become a

premier research organization again. These include focusing on the core competencies of the Agency, forming partnerships and outsourcing with private industry, strengthening acquisition capability within its project manager community, and moving to full-cost accounting. Stewardship of the public dollar requires expertise and technical capability from committed public servants, but the government in essence is relying on buying technical capability rather than maintaining it in-house at NASA, requiring a systematic review of existing and desired capabilities, and how these capabilities are integrated with outside resources to accomplish desired goals in the National interest. If NASA can reprioritize its project portfolio and nurture better buyers within the Agency, it may be able to achieve the goal of “Doing More With Less”.

Critical and Creative Thinking Skills

The dimension of “Critical and Creative Thinking Skills” manifests itself in the required knowledge, skills, abilities, attitudes, and values that result in a more accurate representation of problems, situations, and opportunities, and allows for the exercise of mechanisms that promote and achieve innovative solutions. This applies to both sides of the problem-solving equation, where critical thinking provides the rules to define the requirements of the endeavor in defining the boundaries, and creative thinking allows the team to see how those boundaries can be eliminated or mitigated, intimately tied to managing risk. Another way to view this capability is in terms of convergent and divergent cognitive skills. For the management of science in a Federal bureaucracy, all levels of management should be aligned to the management philosophy of the organization, not just at the top. The temptation to be a hero seems to infiltrate FBC projects, where smart people are expected to overcome major challenges without critical and accurate evaluation of potential risk factors.

Technical Capability

The final workforce development dimension is “Technical Capability”, the expectation that NASA public professionals possess a high degree of technical knowledge and skills, enough to not only provide oversight, but to add value to the program or project by providing insight as a result of their knowledge and experience. This is closely related to the Leadership of Mixed Public/Private Sector Teams. Unfortunately, NASA cannot provide the cutting-edge technical expertise by itself. It needs to leverage external resources so that its workforce maintains a sharp technology and engineering edge, especially if it wants to refocus itself into being a premier research organization.

Interview Samples

Following are sample interview statements that dimensionalize “Workforce Capability”, with the salient data fragment italicized.

Public Service Orientation

“I've heard from many of them that the reason that people come to NASA is because *they're interested in the mission and the work*, and almost always they're turning down or leaving better-paying jobs to do that.”

“The *excitement factor*, and the feeling that what you did actually *meant something, and made a difference*.”

“I do think that the agency is doing some really good things for the nation, and is well worth the taxpayer investment, and, you know, I feel very fortunate to be a small part of that.”

“It means, to me, that what I am doing should be a *direct benefit to the country*, and I should be very responsible with my time and my talents with respect to how I will conduct my business”.

Leadership of Mixed Private and Public Sector Teams

“Another aspect of the *insight versus oversight thing is the notion of being a smart buyer*, and such that NASA wants to be able to have the capability to know when contractors are trying to pull the wool over their eyes, and being able to call the bluff, and those type of things as well.”

“I think the real answer is getting people *emotionally attached to the program*, to the success of the program. *Getting people to buy in*, whether they're the engineers, the technicians, or the business side of the house, they gotta understand how their job relates to the mission success, and they gotta feel like they're a part of the program.”

“I think that the most important aspect of being a good project manager, is, there are two factors. *One is being not a project manager but a project leader who can inspire others to do great things and build a team*. The second most important part of being a good project manager is *understanding risk and how to balance risk, and particularly in a better, faster, cheaper environment*.”

“They went into an environment they didn't understand, and they said we have to succeed so we're gonna rely on the contractor to do everything right. We're

also gonna give the contractor not enough money, and when the contractor tells us he doesn't have enough money, we're not gonna think what is the contractor gonna do to cope with not having enough money? They didn't look at the induced effect of that. They didn't sort of do a risk, environmental risk assessment, and then design a coaching strategy."

Acquisition Capability

"When we build missions, when we build vehicles, or design missions, and so forth, *any vehicle that you build is constructed by hundreds, maybe thousands of contractors*. All that work has to be coordinated and there has to be a collaborative effort, and that's exactly what we're trying to do, is to create an environment where those kind of collaborations can take place, effectively."

"How do we get the most "bang for the buck" in terms of the nation's space capabilities and what the nation achieves in space? In that sense, sometimes, again, not only within a center but *NASA itself can sometimes have a narrow view, that they are the experts in a certain field*, and no one else can possibly have that expertise, or can do as well as they can, or more cheaply than they can, when, in fact, that's not always true."

"One important point is it's not just about routine things like building spacecraft, but, in some areas *NASA wants to "cover the waterfront" in aerospace technology and science*. They want to be the top one in everything, and if they try to do that within any reasonable set of constrained resources, they're not going to do it well.

"NASA has got to do a better job of *not developing something in-house that's commercially available*."

Critical and Creative Thinking

"I think you can set aside a percentage of your budget to try to make some *really big gains*, kind of like the--you know--you can march down a football game, you can march down the field very methodically, and get, you know, games, or every now and then, you can pull out one of those Hail Mary passes, and it may pay off."

"That's the major problem with faster, better, cheaper, is not faster, better, cheaper. It's the people who are doing it, *forgetting that you gotta be aware of the limitations of what you're trying to do*."

"It's a challenge; it's a stretch goal. You come back and say, Dan, I tried my best, boss, but I can't do it in any less than 15 months, and he goes okay. Man, that's great, 'cause I thought it would take you at least eighteen. *I just said twelve because I figured if I didn't get you to work twelve, you'd never figure out, you know, how to get rid of all the inefficiencies.*"

"Stretched--I mean, you know, we looked at how much money he had allocated for quality assurance and said that is an order of magnitude lower than we see. *And what he had done was, you know, I mean, very ingenious. He figured out a way to co-opt the quality people, so they didn't charge him.*"

Technical Capability

"It was very beneficial in several ways. *First of all, I got hardware experience. I understood what it means to actually deliver a product to a bottom line, you know, where a company's got to make a profit.*"

"We're in an environment now where I, personally, and I don't know a whole lot of other people that have the time, but *we just don't have the time to do that, and so we achieve a level of training and knowledge, and it's kept up by going to a 1-week course here and a 2-week course there.*"

"*You should spend time in the engineering department; you should spend time in a research branch, understanding what it means to do fundamental research in support of these missions. You should spend time on the floor, integrating hardware, and then, once you've understood what all the pieces are, you need to pick, you should be able to pick which area you want to focus on.*"

"They were bringing people online that were new hires, that were people who didn't fully understand the system, but they didn't have time, their experts were working the current mission and didn't have time to do the next set, and they were trying to bring in and train them at the same time, and everybody is so overworked that simple things get missed."

Document Analysis

Several NASA documents were analyzed to see whether the summary data categories could be further saturated. These documents contained a rich description of the elements of FBC, sometimes within the context of other management philosophies. Overall, these documents did not add any new considerations to the interview data already collected, but did validate that the summary categories were the correct concepts to move forward into a substantive level theory.

NASA Strategic Plan

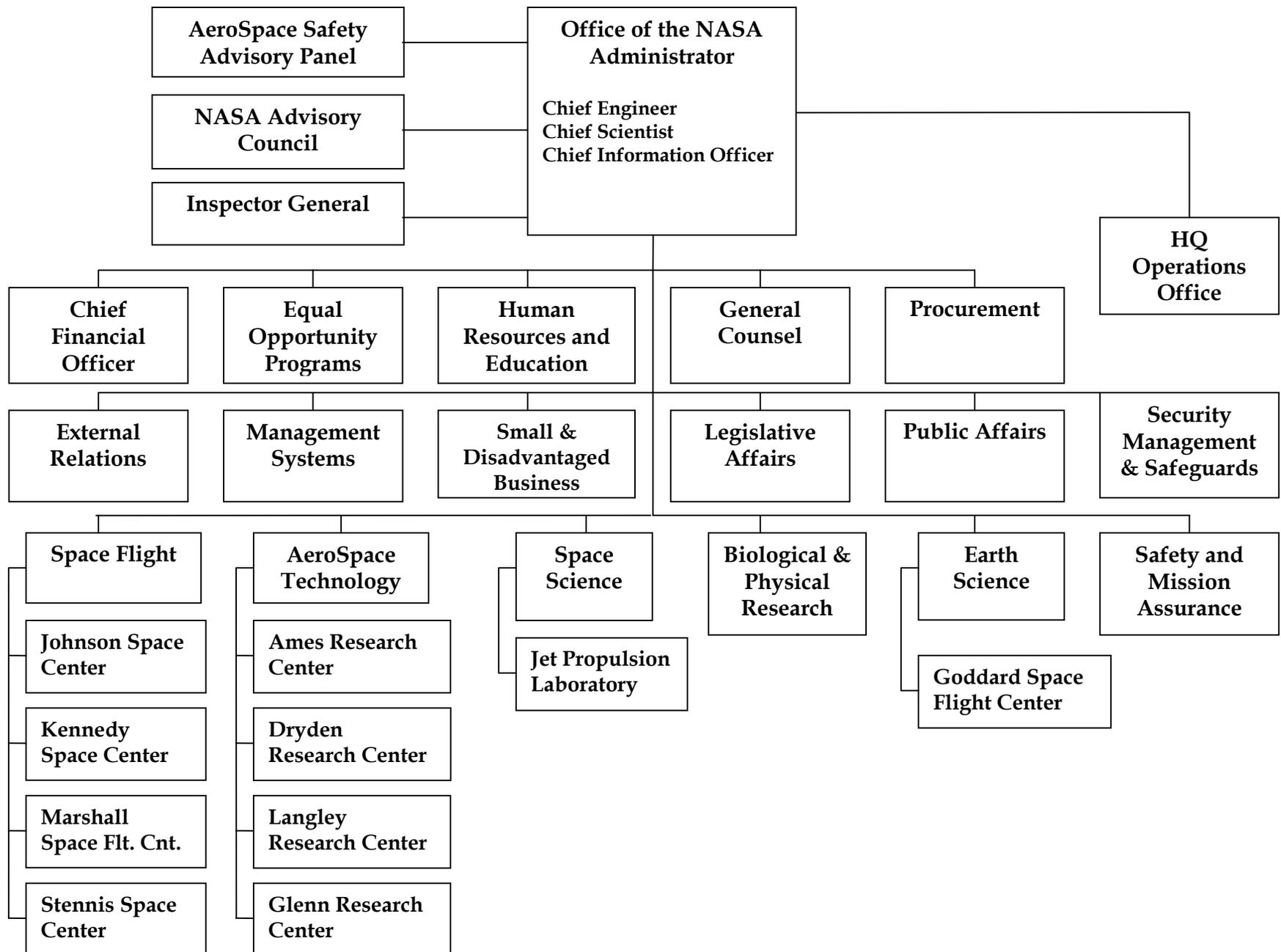
The NASA Strategic Plan (1998) outlines the vision, mission, values, goal, objectives, strategies, and roadmaps for the organization. Of four espoused key values, safety first and excellence in terms of continuously improving products, processes, and services influence the philosophy of FBC. NASA is organized into five strategic Enterprises of Space Science, Earth Science, Human Exploration and Development of Space, Aerospace Technologies, and Biological and Physical Research. The goals and objectives of the Enterprises reflect the desire of the Agency in emphasizing faster return on investment, improved capability in conducting missions, and affordability. The Agency also identifies four crosscutting processes in the NASA Strategic Management Handbook (2000). These processes are called managing strategically; providing aerospace products and capabilities; generating knowledge; and communicating knowledge. The crosscutting processes were developed to emphasize effectiveness and efficiency in conducting NASA operations. Both plans document the public service aspect of the previous data analysis, specifying the nature of service to the country and illustrating the exciting and unique work that is available in the organization. To achieve the vision and missions set out in this plan, NASA is organized as shown in Figure 1. It is important to note that the Centers are organized under their particular Enterprise mission, and that both overall Agency priorities and Enterprise priorities coexist for NASA as an organization.

The Spear Report

In July 1999, Dan Goldin tasked Tony Spear, the former Mars Pathfinder project manager and a successful practitioner of FBC, to undertake a study of FBC project implementation within NASA and to assess FBC best practices (NASA FBC Final Report, 2000). The study could not resolve the various definitions of FBC that exist across NASA, but concluded that FBC consists of the three major elements of people, methods, and technology, and boils down to two basic things: FBC applies to everyone and everything and is simply attempting to improve performance by being more efficient and innovative, and there is an intangible element of team spirit associated with doing FBC, with people being the most important ingredient.

The report emphasizes that FBC projects are characterized by specific attitudes, to include not accepting past practices without good reason; continuously looking for improvement; stepping out with new methods and new technology; taking prudent risk and not taking undue risk by taking shortcuts under pressure around important tests and qualifications; applying discipline through careful upfront planning, design and implementation; keeping past lessons learned out in front at all moments; being checked, balanced and mentored by experienced personnel; emphasizing that the project manager is the final authority; and ensuring the project organization is structured to be candid and open to encourage honest communications.

Figure 1: NASA Organization



The report goes on to say that there are three “badges of courage” that represent graphic measures of project performance. They are certification of the project manager and team members in terms of experience and expertise, the development of programmatic and mission risk signatures, and a performance metric that reflects how well the project is operating and implementing according to FBC “rules of engagement”.

High Speed Research (HSR) Case Study

The HSR case study (National Aeronautics and Space Administration, 1997) covers the story of the High Speed Civil Transport, designed to ensure the preeminence of the United States aeronautical industry. Early in the program, it was determined that an equal partnering arrangement would be developed with industry, with industry designated as the ultimate customer, not NASA. NASA Centers would also need to partner within themselves in order to avoid duplication of efforts and to send the work to the partner that possessed the greatest core competency to achieve the desired results. Partnering did not come easy to NASA and industry due to the lack of experience in the area of consensus management. Because of this, project members estimated that fully one-quarter of the time was devoted to maintaining and opening lines of communications, leveraging information technology as much as possible to overcome organizational and geographical boundaries. The consensus management approach used in this program provided several advantages for the combined public sector and private sector team, including:

- A diverse knowledge base to deal with complex problems.
- Better coordination through information sharing practices.
- Better team learning through shared technical experiences and shared ideas.
- The ability to share resources across several NASA facilities and industry location.

The conclusions of the study point to success achieved by the project due to common vision through a systems engineering emphasis, customer involvement and continuous improvement, collaboration and teaming through collocation of critical efforts, a consensus management approach, and using technology and clearly defined metrics and criteria to assist with geographic dispersion, decision-making, and risk analysis.

Miniature Seeker Technology Integration (MSTI) Case Study

The MITI project (National Aeronautics and Space Administration, 1997) was a rapid development spacecraft, designed and launched in November 1992 within a one-year period of time, operated under the FBC management criteria agreed upon between NASA and its industry partners, accomplishing and exceeding all mission requirements. This successful experience led JPL to adopt an approach called “Fast Track Procurement” and led to significant changes in JPL’s culture that endure to this day, including the Flight System Test Bed and the Mission Design Center.

The aggressive schedule was a key driver in the optimization of the whole system of developing low-Earth orbit spacecraft, leading to the necessity of faster design, faster procurement, and clear cost control. Rapid prototyping and testing of the system enabled engineers to substitute subsystems and make tradeoffs very rapidly, delivering proposals in a matter of days. The engineers learned to use design margins to reduce the level of optimizing at the subsystem level and enable them to take advantage of existing hardware architectures. Information technology allowed for efficient change requests, and daily meetings encouraged the early identification of problems. Collocation of the quality assurance personnel with the engineers also encouraged early identification of problems.

Technical and procurement personnel formed procurement teams that allowed for close coordination and allowed a Request-for-Proposal (RFP) to contractor selection cycle of a minimum of 33 days. Information technology in the form of Web-based electronic bulletin boards allowed for quick answers to questions. The proposal format was also modified to allow for fast proposal development and evaluation, with follow-up site visits and detailed cost development leading to a final contract negotiation.

The project team was given more responsibility, and responded with streamlined decision-making processes, role-sharing, and increased information exchange. The common vision of creating and launching a spacecraft within one year was a non-negotiable target for the entire team. Senior management support also allowed for shielding of the project from political factors.

Near Earth Asteroid Rendezvous (NEAR) Project

The NEAR project (National Aeronautics and Space Administration, 1997) was an outgrowth of the Discovery program, an effort that resulted from the desire by scientists to retrieve data from space faster, reports that recommended that the scientific community should have first priority for resources, and Congressional pressure to provide more science leadership responsibility in a planetary program characterized by low cost. The purpose of the Discovery program was to accomplish high-quality, focused planetary science utilizing innovative, streamlined, and efficient management

approaches. NEAR was launched in February 1996, under budget, developed in 27 months, and was a robust spacecraft and payload with acceptable risk and possessing the required scientific scope.

There were several lessons learned from the project experience that the personnel believed led to success. These were:

- A clear vision of putting science first, involving the primary customer up-front, emphasizing a systems engineering perspective.
- Creating a clear set of operating values and principles.
- Establishing a tailored system of incentives and rewards to stakeholders.
- Optimize the number of NASA personnel, preventing unneeded oversight activity.
- Establishing a small, empowered, experienced technical team.
- Creation of a high-level, simple schedule, managed by lead engineers for each subsystem.
- Requiring that quality personnel report directly to the project manager.
- Employ design-to-cost principles for reliability and redundancy.

NASA Inspector General Audit of Faster, Better, Cheaper

In March 2001, the NASA Inspector General (IG) released a report that audited the implementation of FBC within NASA (NASA FBC Policy, Strategic Planning, and HR Alignment, 2001). The IG considered that FBC was a management policy that needed to be defined, supported in policy documents, and incorporated into the strategic planning process of the Agency.

FBC had been used as an approach since 1992, but the IG could not find any definitions of FBC, any policy documents that supported FBC, or any FBC goals, objectives, or metrics in the strategic plan. In addition, the human resources needed to be aligned with the implementation of FBC were not defined, creating a lack of determination in the amount of appropriate staff and competencies required to carry out FBC programs and projects. Based on these findings, the IG recommended that NASA define FBC; develop policies and guidance to describe FBC implementation; incorporate FBC into the strategic management process; and align staffing with strategic needs.

General Accounting Office Knowledge Management Study

In January 2002, the General Accounting Office (GAO) issued the results of a survey covering the status of knowledge management within NASA. In this report, the GAO said that inefficient technology and a reluctance to discuss past failures are keeping NASA managers from sharing important lessons with one another (Government Accounting Office Lessons Learned Report, 2002).

In the report, the GAO emphasized that in order to achieve FBC, the knowledge management processes and procedures were key, especially in light of failure review boards for FBC projects that suggested that NASA was not applying lessons learned from past experiences, both successes and failures, to current programs and projects. Table 1 from the GAO report covers reasons for spacecraft failures, all of which were known prior to the most recent FBC failures.

Findings

The descriptions and definitions of operating in an FBC environment within NASA allowed the interview participants to discuss in detail and at length their views on how to be successful in that type of work environment. The analysis of the data concerning FBC revealed several findings. A summary of these findings follows, with a complete discussion of the findings contained in Chapter Five of this document.

Finding #1

The first finding provides context to Research Question #1, emphasizing that changes occurring in the Federal sector are permanent in terms of the budget and emphasis on results and performance. The FBC management philosophy outlines a set of desired outcomes that NASA strives for within resource constraints. Former NASA Administrator Dan Goldin's FBC philosophy may have preserved research priorities against operational program budget overruns.

Finding #2

The second finding addresses Research Question #1 on the meaning of FBC for NASA and its stakeholders. The use of the terms "faster" and "cheaper" possesses intuitively understandable definitions as applied to schedule and cost constraints for project outcomes. The term "better" depends on the context of the functional environment where it is used, and at what level of the organization it is used. Regardless, the term "better" connotes both continuous improvement and revolutionary improvement in both the research and mission operations world, and is tied to the use of improved technologies, requiring a system for learning of lessons provided by research and previous missions.

Table 1: Reasons for Selected Spacecraft Failures

Reasons for Spacecraft Failure	Broad Area Review Major Program Review	Lockheed-Martin Independent Assessment Team Major Program Review	FBC Task Force Major Program Review	Wide-Field Infrared Explorer Project Mishap Review	Mars Climate Orbiter Project Mishap Review	Mars Polar Lander Mishap Review	Lewis Project Mishap Review	Solar & Heliospheric Observatory Project Mishap Review	Mars Observer Project Mishap Review	Delta-Clipper Project Mishap Review	Challenger Program Mishap Review
Cost and Schedule Constraints	•			•			•		•		•
Insufficient Risk Assessment and Planning		•	•		•	•	•	•	•	•	•
Underestimation of Complexity and Technology Maturity	•		•				•	•	•		
Insufficient Testing			•	•	•		•		•	•	•
Poor Team Communications	•	•	•	•	•	•	•	•			•
Inattention to Quality and Safety	•	•	•		•						•
Inadequate Review Process	•	•	•	•	•	•	•	•		•	•
Design Errors	•			•	•	•			•	•	•
Inadequate Systems Engineering	•	•	•	•	•	•	•	•	•		
Inadequate or Undertrained Staff	•	•			•	•		•	•	•	•

Finding #3

The third finding covers FBC requirements and constraints and addresses Research Question #2. The type of mission plays a significant role in the application of the FBC management philosophy. This emerges as a key difference in the application of FBC in operations versus research communities within NASA, and the activity of comparing to an internal or external baseline can be critical to the definition of “better”, whether it is a previous effort, the effort of a competitor, or comparison to customer expectations of what is possible to accomplish. The matching of FBC tools and techniques to the appropriate projects is also a key element of managing the risk, especially in terms of unmanned versus manned systems, but this is not currently done since the Agency does not manage programs and projects as a portfolio prioritized by risk.

Finding #4

The fourth finding is that NASA may not be organized to easily apply the management philosophy of FBC, addressing Research Question #3. Senior management does not seem willing to formalize FBC, resulting in some miscommunication throughout the organization. Public professionals may not be able to engage in proactive behavior that could result in improved trade-offs and policy development, implementation, and evaluation that would better balance priorities. A change needs to occur in the process that allows for a more accurate determination of requirements, constraints, and innovation to occur, including lessons from basic research and previous missions. The parochial nature of the Centers sometimes prevents the efficient importing of technologies and methods that will assist NASA in meeting its responsibilities.

Finding #5

The fifth finding is that there are general competency categories that are necessary for FBC to be effectively and efficiently implemented, addressing Research Question #4. These capabilities are called public service orientation, leadership of mixed private and public sector teams, acquisition capability, critical and creative thinking skills, and technical capability.